J. Agric. Sci. Technol. (2004) Vol. 6: 103-110

Growth and Seed Characteristics of Isabgol (*Plantago ovata* Forsk) as Influenced by some Environmental Factors

G. Karimzadeh[1*] and R. Omidbaigi[2]

ABSTRACT

Isabgol (*Plantago ovata* Forsk), is an annual herb cultivated as a medicinal plant in recent decades. Its seed contains mucilage, fatty oil, large quantities of albuminous matter, a pharmacologically inactive glucoside, namely Aucubin ($C_{13}H_{19}O_8H_2O$), and a plantiose sugar. Medicinal plants are rich in secondary metabolites: their biosynthesis is controlled genetically and is affected strongly by environmental factors. In the present work, the influence of sowing dates (20th April, 5th and 20th May) and nitrogen-fertilizer levels (0, 50, 100 and 150 kg ha^{-1}) was examined on the growth, seed yield and seed swelling factor (content of mucilages) of isabgol. The statistical design was a split-plot arrangement of a randomized complete block design with three replicates: the sowing dates and nitrogen fertilizer were considered as the main and sub-main plots, respectively. The plot experiment was installed in the experimental station of Zanjan region located in the northwest of Iran, under silty-clay soil conditions. According to the resulting data, the best time for sowing isabgol in such a region was 5th May and the suitable amount of nitrogen fertilizer was 100 kg ha^{-1}. To discover any relationship, all measured independent variables were muliple regressed on the dependent variable (seed yield) followed by stepwise regression analysis. This verified that the seed yield among other independent characteristics tested appeared to show a significant positive effect on the seed swelling.

Keywords: Environmental factors, Isabgol, N-Fertilizer, *Plantago ovata*, Sowing date, Swelling factor, Zanjan, (Iran).

INTRODUCTION

Isabgol (*Plantago ovata* Forsk) is a 10-45 cm short-stemmed annual herb belonging to the Plantaginaceae family which is known by different names, such as ashwagolam, aspaghol, aspagol, bazarqutuna, blond psyllium, ch'-ch'ientzu, ghoda, grappicol, Indian plantago, Indische Psylli-samen, isabgul, isabgul gola, ispaghula, isphagol, vithai, issufgul, jiru, obeko, psyllium, plantain, spogel seeds (Kapoor, 1990; Farnsworth, 1995; Galindo *et al*., 2000; Anonymous, 2002). Its leaves are born alternately on the stem or in rosettes addressed to the soil surface. Leaf count per plant varies between 40-86 and it is strap shaped recurved, linear 6.0-25 cm long and 0.3-1.9 cm broad. Leaf surface is glabrous or slightly pubescent. Spikes are cylindrical or ovoid and measure 0.6-5.6 cm. Flowers are arranged on the spike, in four spiral rows. Sepals are four, free, concave, glabrous and elliptic and petals are four, glabrous, reflexed and white in colour. The ovary is bilocular with single ovule per locule and the placentation is axile. The capsule is ovate or ellipsoid, dehiscing along the ring of abscission tissue which is

[1] Department of Plant Breeding, College of Agriculture, Tarbiat Modarres University, P. O. Box: 14115-336, Tehran, Islamic Republic of Iran. e-mail : karim_gh@modares.ac.ir
[*] Corresponding author
[2] Department of Horticulture, College of Agriculture, Tarbiat Modarres University, P. O. Box: 16415-381, Tehran, Islamic Republic of Iran.



developed around the capsule (Parsa, 1951; Lamba and Gupta, 1981; Chevallier, 1996). Isabgol seeds are cymbiform, translucent and concavo-convex in shape and they are pinkish-gray, brown or pinkish-white with a brown streak in colour (Handa and Kaul, 1999). Isabgol is grown in warm temperate regions between 26-36°N, latitude, its species are indigenous to the Mediterranean region and west Asia extending up to west Pakistan (Koul and Sareen, 1999; Baghalian, 1999).

Isabgol has been used in medicines since ancient times, but it has only been cultivated as a medicinal plant in recent decades (Gupta, 1987; Wolver *et al*., 1994; Lal *et al*., 1999; Handa and Kaul, 1999). Its seed contains mucilage, fatty oil, large quantities of albuminous matter, the pharmacologically inactive glucoside, namely Aucubin (C_{13} H_{19} O_8 H_{2O}) and a plantiose sugar (Chevallier, 1996). Isabgol seed husk has the property of absorbing and retaining water which accounts for its utility in stopping diarrhoea. It is a diuretic, alleviates kidney and bladder complaints, gonorrhea, arthritis and hemorrhoids (Zargari, 1990; Ansari and Ali, 1996). In general, plants known as medicinal are rich in secondary metabolites and have potential as drugs. The biosynthesis of the secondary metabolites is controlled genetically and affected strongly by environmental factors (Yanive and Palevitch, 1982; Omidbaigi, 2000), of which the sowing date is a prerequisite for assuring optimal ecological conditions during the plant growth and development. In this context, at Jammu, the sowing of isabgol is proposed to be ideal between mid-October and mid-November. Late sowing, when winter starts raining is over, adversely tells upon seed yield due to a short growth period (Koul and Sareen, 1999). However, Kalyansundram *et al*. (1984) reported that sowing of *Plantago ovata* during the first week of December is considered to be ideal. Concerning the effect of nitrogen on *Plantago ovata*, Koul and Sareen (1999) pointed out that if the quantity of nitrogen applied increases from 0 to 50 kg ha^{-1}, it induces a reduction in both nitrogen concentration and the swelling factor of *Plantago* seeds. Randhawa *et al*. (1985) reported that an increase in the seed yield results from an increase in nitrogen application. In the Tarai area, the highest seed yield has been recorded following the application of 40-80 kg ha^{-1} nitrogen (Singh and Nand, 1988).

This study was aimed at discovering the effect of some environmental factors, such as the suitable sowing date and nitrogen-fertilizer, which could be used for isabgol cultivation to increase the quantity of and improve the quality of isabgol productivity as well as to clarify the relationship between measured characteristics.

MATERIALS AND METHODS

The isabgol plants were grown in a silty-clay soil with good drainage. The statistical design used was a split-plot arrangement of a randomized complete block design with three replicates of each treatment. The sowing dates were considered as the main plot, consisting of the 5th and 20th April, and 5th and 20th May. Note that seeds sown on 5th April were first grown normally but they were then discarded because of chilling stress occurred. Hence, the other three sowing dates (20th April, and 5th and 20th May) were considered for the present work. Seeds were sown in sub-plots in rows 30 cm apart and spaced 5 cm apart and the effect of nitrogen fertilizer was studied in sub-plots. An untreated control (0 level) in addition to three different nitrogen levels of 50, 100 and 150 kg ha^{-1} were used in the form of urea. Nitrogen was utilized twice: half of it was used two days before sowing and the other half was used at the flowering stage. Plant height, the number of flowers and branches per plant, average seed weight and the swelling factor were measured. After 24 hours of submerging 1 g of seeds in 20 ml dH_2O, the swelling factor was measured. This work was carried out in the experimental station (36º 40'N latitude, 48º

26' altitude, 1634 m see level) of Zanjan located in northwest of Iran. The station climatic conditions are semi-arid and moderately cold with 263 mm annual precipitation. The mean annual lowest and highest temperatures are 3.9°C and 18°C, respectively. The soil characteristics are as follows: 15% sand, 45% clay, 40% silt, pH 7.6, 334 ppm K, 7.8 ppm P, 0.082 ppm total N and 0.82% organic C. According to this analysis, the amount of 100 kg ha^{-1} triple super phosphate with 46% active substance was added to the soil. To identify any relationship, we regressed the plant height, number of branches and flowers per plant, weight of 1000 seeds and seed yield as independent variables and the seed swelling as a dependent variable, using the Minitab Statistical Software Package (Ryan and Joiner, 2001). Moreover, a stepwise multiple regression analysis was computed to examine the statistically significant independent variables influencing the dependent variable (seed swelling) and formulating it. The statistical mean comparisons were calculated according to Duncan's Multiple Range test (LSR).

RESULTS

Effect of Sowing Date

ANOVA (Table 1) showed that the sowing date had highly significant effects on plant height, number of branches and number of flowers per plant, seed yield ($P<0.001$), swelling factor ($P<0.01$) and weight of 1000 seeds ($P<0.05$). The mean comparisons of the above-mentioned characters are given in Table 2. The plants which were planted on 5th May grew much better compared with those planted on 20th May (Table 2). On the other hand, seeds sown on 5th May showed significantly ($P<0.01$) more swelling compared to those sown on other dates (Figure 1). Hence, it can be concluded that the sowing date played an important role on the growth parameters and seed characteristics of *Plantago ovata*. Isabgol seeds apperard to be cold sensitive, hence, they should not be sown in the early Spring. According to the resultant data, 5th May is suggested as the best sowing date for *Plantago ovata* at the above-mentioned experimental station.

Table 1. Analysis of variance for six growth characteristics of *Plantago ovata*.

Source of Variation	Df	Mean Squares (MS)					
		Plant Height (cm)	No. of Branches per $Plant^{-1}$	No. of Flowers per $Plant^{-1}$	1000 Seed Weight (g)	Seed Yield ($g\ m^{-2}$)	Swelling Factor (mm)
Block	2	1.251^{ns}	0.025^{ns}	0.414^{ns}	0.05^{ns}	8.651^{ns}	0.09^{ns}
Sowing Date (A)	2	147.679^{***}	32.077^{***}	53.534^{***}	0.285^{*}	2695.736^{***}	15.715^{**}
Error 1	4	1.254	1.521	2.824	0.025	7.936	0.392
Nitrogen (B)	3	8.903^{***}	5.939^{***}	13.336^{***}	0.192^{***}	379.009^{***}	5.933^{***}
AB	6	0.832^{ns}	0.402^{ns}	0.882^{ns}	0.014^{ns}	41.039^{***}	0.252^{**}
Error 2	18	0.355	0.172	0.401	0.024	5.542	0.069

^{ns} Non Significant at 0.05 probability level
$^{*, **, ***}$ Significants at 0.05, 0.01 and 0.001 probability levels, respectively.



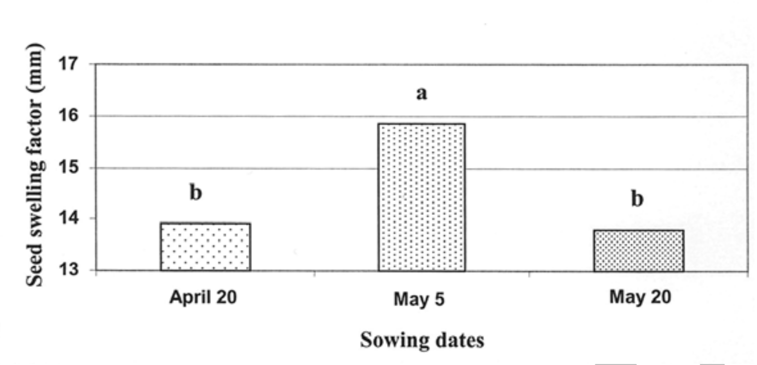


Figure 1. Effect of Sowing dates on the seed swelling factor of *Plantago ovata*. Histograms with the same latter symbols, according to Duncan's multiple range test, are not significantly (P<0.05) different from each other. The bars show ± Se.

Effect of Nitrogen-Fertilizer

ANOVA (Table 1) exhibited that the N-fertilizer significantly (P<0.001) influenced all of the growth and seed characters and the swelling factor measured in this experiment. The mean comparisons of the these characters are demonstrated in Table 3. The utilization of 100 kg ha^{-1} of N-fertilizer for this plant appeared to show the best results on most of the growth characters. The highest seed swelling (15.6 mm) also resulted from Isabgol seeds treated with this amount of nitrogen (Figure 2). Therefore, It can be deduced that the best treatment for cultivation of *Plantago ovata* is to use 100 kg ha^{-1} nitrogen, applying half of it before seed sowing and the other half at flowering stage.

Relationship among Measured Characteristics

Plant breeders need production measurement of given traits to improve plant characteristics. To formulate the relationship between five independent growth variables measured in our experiment, with a dependent variable, multiple regression analysis was carried out for the plant height, number of branches and flowers per plant, weight of 1000 seeds and yield as independent variables and seed swelling as a dependent variable. The multiple regression

Table 2. The means ± Se of growth and seed characteristics of Plantago ovata from different sowing dates.

Sowing Date	Plant Height (cm)	No. of Branches per Plant^{-1}	No. of Flowers per Plant^{-1}	1000 Seed Weight (g)	Seed Yield (g m^{-2})
April 20	11.41 ± 0.32 ^{b}	3.23 ± 0.18 ^{b}	4.51 ± 0.25 ^{b}	5.90 ± 0.05 ^{b}	64.82 ± 0.83 ^{b}
May 5	18.06 ± 0.46 ^{a}	5.67 ± 0.32 ^{a}	8.18 ± 0.53 ^{a}	6.20 ± 0.04 ^{a}	91.04 ± 2.74 ^{a}
May 20	16.68 ± 0.17 ^{a}	6.34 ± 0.29 ^{a}	8.16 ± 0.38 ^{a}	6.05 ± 0.65 ^{ab}	65.28 ± 1.84 ^{b}

Means followed by the same letter symbols in each column-according to Duncan's multiple range test - are not significantly (P<0.05) different from each other.

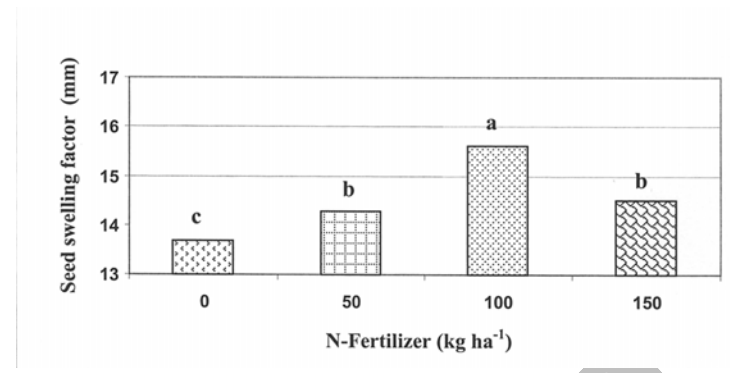


Figure 2. Effect of nitrogen-fertilizer levels on the seed swelling factor of *Plantago ovata*.

equation is shown as follows:

Seed swelling = 7.18 - 0.00185 (X1) + 0.0063 (X2) - 0.0031(X3) + 0.328 (X4) + 0.0824 (X5).

Where:

X1 = Plant height (cm),

X2 = No. of branches plant^{-1},

X3 = No. of flowers plant^{-1},

X4 = 1000 seeds weight (g),

X5 = Seed yield (g m^{-2}),

Seed swelling (mm),

7.18 = Constant value.

Furthermore, the stepwise regession analysis was also carried out for the data obtained to test the significance of the independent variables shown in the above equation affecting the seed swelling as a dependent variable. Therefore, the resulted stepwise regression equation is shown as follows:

Seed swelling = 8.874 + 0.0765 (Seed yield)

R^2 = 75.4%

This equation indicates that only the seed yield trait among other independent variables tested showed a significant positive effect ($P<0.05$) on seed swelling. In other words, with increasing of 1 g of seed yield, 0.0765 mm of seeds swelled.

DISCUSSION

Plants known as medicinal are rich in secondary metabolites and have potential as drugs. The biosynthesis of the secondary metabolites of the medicinal plants is under genetic control, and environmental factors play an important role (Yanive and Palevitch, 1982; Omidbaigi, 2000). Environmental factors such as cultivation practices (such as sowing date, fertilizer

Table 3. The means ± Se of growth and seed characteristics of *Plantago ovata* in different N-fertilizer levels.

N–Fertilizer (kg ha^{-1})	Plant Height (cm)	No. of Branches per Plant^{-1}	No. of Flowers per Plant^{-1}	1000 Seed Weight (g)	Seed Yield (g m^{-2})
0	14.13 ± 0.97 ^{c}	4.16 ± 0.40 ^{c}	5.46 ± 0.47 ^{c}	5.94 ± 0.072 ^{b}	66.78 ± 3.44 ^{d}
50	15.21 ± 1.07 ^{b}	4.69 ± 0.48 ^{b}	6.49 ± 0.64 ^{b}	6.02 ± 0.043 ^{b}	71.22 ± 4.07 ^{c}
100	15.67 ± 1.02 ^{b}	5.97 ± 0.65 ^{a}	8.16 ± 0.81 ^{a}	6.27 ± 0.070 ^{a}	82.13 ± 5.67 ^{a}
150	16.52 ± 1.11 ^{a}	5.51 ± 0.49 ^{a}	7.69 ± 0.73 ^{a}	5.98 ± 0.076 ^{b}	74.80 ± 4.45 ^{b}

Means followed by the same letter symbols in each column-according to Duncan's multiple range test - are not significantly ($P<0.05$) different from each other.



level and water supply) have marked effects on plant growth and the production of secondary metabolities (Yanive and Palevitch, 1982; Randhawa *et al*., 1992). In this work, sowing dates showed conspicuous effects on all growth and seed characteristics examined on *Plantago ovata*. These data are in agreement with those reported by Koul and Sareen (1999). Isabgol seeds sown on 5th April were first grown normally but they were then discarded because chilling stress occurred. According to this, it can be deduced that isabgol is chilling sensitive, therefore, its seeds should not be sown in the early spring. In other words, early spring cold in the Zanjan region can damage the emergence of isabgol seeds and potentially restricts the early seed growth. According to such resultant data, among three sowing dates studied, 5th May is suggested as the best sowing date for *Plantago ovata* at the Zanjan experimental station.

Furthermore, all of the growth characteristics and the swelling factor of Isabgol were clearly influenced by nitrogen fertilizer in the present work, leading to the dedvetion that the best treatment for cultivation of *Plantago ovata* is to use 100 kg ha^{-1} nitrogen in the above-mentioned experimental station, applying half of which as pre-sowing and the other half at flowering stage. These findings are in agreement with the results reported by other workers (Singh and Nand, 1988; Ramash *et al*., 1989; Ganpat *et al*., 1992). Meanwhile, in the present work, the highest seed swelling also resulted from Isabgol seeds grown under 100 kg ha^{-1} of nitrogen. The stepwise regression analysis verified that the seed yield among other growth and seed characteristics studied in this work had a marked increasing effect on the seed swelling factor.

REFERENCES

1. Anonymous, 2002. Monograph: *Plantago ovata* (Psyllium). *Alternative Medicine Review*, **7(2)**: 155-159.
2. Ansari, S. H. and Ali, M. 1996. Chemical, Pharmacological and Clinical Evaluation of *Plantago ovata* Forsk. *Hamdard Medicus,* **39**: 63-85.
3. Baghalian, K. 1999. Effects of Air Humidity and Soil Moisture on Quality and Quantity of Mucillage in Seed of *Plantago ovata* Forsk. M. Sc. Thesis, University of Tehran, Iran.
4. Chevallier, A. 1996. *The Encyclopedia of Medicinal Plants*. Dorling Kindersley, London, UK.
5. Farnsworth N. R., 1995. (Ed.) *NAPRALERT Database*. Production of University of Illinois at Chicago, IL, August 8, 1995 (an on-line database available directly through the University of Illinois at Chicago or through the Scientific and Technical Network (STN) of Chemical Abstracts Services).
6. Galindo, P. A., Gómez, E., Feo, F., Borja, J. and Rodriguez, R. G. 2000. Occupational Asthma Caused by Psyllium Dust (*Plantago ovata*). In: *The 6th Internet World Congress for Biomedical Sciences*. Available on http://www.uclm.es/inabis2000/posters/pdf/p085.pdf.
7. Ganpat, S., Ishawar, S., Bhati, D. S. and Singh, G. 1992. Response of *Plantago ovata* to Irrigation and Split Application of Nitrogen. *Indian. J. Agr. Sci*, **37**: 880-881.
8. Gupta, R. 1987. *Medicinal and Aromatic Plants. Handbook of Agriculture,* Indian Council of Agriculture Research, New Delhi, India, pp. 1188-1224.
9. Handa, S. S. and Kaul, M. K. 1999. *Supplement to Cultivation and Ctilization of Medicinal Plants*. Regional Research Laboratory Council of Scientific and Industrial Research, Jammu-Tawi, India.
10. Kalyansundram, N. K., Sriram, S., Patel, B. R., Patel, D. H., Dalal, K. C. and Gupta, R. 1984. Psyllium: A Monopoly of Gujarat. *Indian Hort*., **28**: 35–37.
11. Kapoor L. D. 1990. *Handbook of Ayurvedic Medicinal Plants*. CRC Press, Boca Raton, Florida, pp. 267.
12. Koul, A. K. and Sareen, S. 1999. *Plantago ovata* Forsk: Cultivation, Botany, Utilization and Improvement. In: "*Supplement to Cultivation and Utilization of Medicinal Plants*." (Eds.): Hand, S. S. and Kaul, M. K. Regional Research Laboratory Council of Scientific and Industrial Research, Jammu–Tawi, India. PP. 477–495.

13. Lal, R. K., Sharma, J. R. and Misra, H. O. 1999. Induced Variability and Varietal Selection in Isabgol (*Plantago ovata*). *J. Med. Arom. Plant Sci*., **21**: 34-37.
14. Lamba, L. C. and Gupta, V. 1981. Anatomy of Circumscissile Dehisscence in *Plantago ovata* Forsk. *Curr. Sci*., **50**: 241-243.
15. Omidbaigi, R. 2000. Approaches to Production and Processing of Medicinal Plants. Tarrahane Nashr Pub., Tehran, Iran.
16. Randhawa, G. S., Gill, B. S. and Raychaudhuri, S. P. 1992. Optimising Agronomic Requirements of anise (*Pimpinella anisum* L.) in the Punjab. In: *Recent Advances in Medicinal, Aromatic and Spice Crops*. Vol. 2. International Conference, 28-31 January, New Delhi, India. pp. 413-416.
17. Parsa, A. 1951. *Flore de l' Iran*, Vol. 1. University of Tehran, Iran.
18. Ramash, M. N., Farooqi, A. A. and Subbaiah, T. 1989. Influence of Sowing Date and Nutrient on Growth and Yield of Isabgol (*Plantago ovata* Forsk). *Crop Res. Hisar*., **2**: 169-174.
19. Randhawa, G. S., Mahey, R. K., Saini, S. S. and Sidhu, B. S. 1985. Studies on Irrigation Requirements of *Plantago ovata*. *Indian J. Agron*., **30**: 187-191.
20. Ryan, B. G. and Joiner, B. L. 2001. *Minitab Handbook*, 4th Edn. Duxbury Press, USA.
21. Singh, J. N. and Nand, K. 1988. Effect of Nitrogen Levels and Row Spacings on Seed Yield of Psyllium. *Ind. Drugs*, **25**: 459–461.
22. Wolver, T. M. S., Jenkins, D. J. A., Mueller, S., Boctor, D. L. and Ransom, T. P. P. 1994. Method of Administration Influences the Serum Cholesterol-lowering Effects of Psyllium. *Amer. J. Clinic. Nutrit*., **59**: 1055-1059.
23. Yanive, Z. and Palevitch, D. 1982. Effect of Drought on the Secondary Metabolites of Medicinal and Aromatic Plants. In: "*Cultivation and Utilization of Medicinal Plants*". (Eds.): Atal, C. K. and Kapur, B. M., CSIR Jammu-Tawi, India, pp. 1-22.
24. Zargari, A. 1990. *Medicinal Plants*. Vol. 4, University of Tehran Pub., Tehran, Iran.

رشد و خصوصيات بذري اسفرزه (*Plantago ovata* **Forsk**) تحت تأثير برخي فاكتورهاي محيطي

ق. كريم زاده و ر. اميدبيگي

چكيده

اسفرزه (*Plantago ovata* Forsk) گياهي يكساله علفي است كه بعنوان گياه دارويي در سال هاي اخير كشت مي‌شود. بذرهاي آن حاوي تركيبات لعابي به نام موسيلاژ ، اسيد چرب، مقدار زيادي از مواد آلبينوز، گلوكوزيد غير فعال از نظر داروسازي به نام يوسوبين ($C_{13}H_{19}O_8H_2O$) و قند پلانتوز مي باشد. گياهان دارويي غني از متابوليسم ثانويه است كه بيوسنتز آنها تحت كنترل ژنتيكي و فاكتورهاي محيطي است. در اين تحقيق ، اثر تاريخ هاي كاشت (31 فروردين ، 15 و 30 ارديبهشت ماه) و سطوح كود نيتروژن (0 ، 50 ، 100 و 150 كيلوگرم در هكتار) در قالب طرح آماري كرت‌هاي خرد شده با طرح پايه بلوك هاي كامل تصادفي با سه تكرار بر روي رشد، عملكرد بذر و فاكتور تورم بذر (مقدار موسيلاژ ها) اسفرزه مورد مطالعه قرار گرفت. در اين طرح، تاريخ‌هاي كاشت و كود نيتروژن به ترتيب بعنوان كرت‌هاي اصلي و كرت هاي فرعي منظور شد. اين آزمايش در قطعه‌اي



از زمین‌هاي ایستگاه تحقیقاتي زنجان واقع در شمال غربي ایران در شرایط خاکي لومي - رسي اجرا گردید. بر اساس نتایج حاصله، بهترین زمان براي کاشت اسفرزه در این منطقه 15 اردیبهشت و مقدار مناسب کود نیتروژن 100 کیلوگرم در هکتار بوده است. به منظور مطالعه و نحوة تأثیرگذاري متغیرهاي مستقل بر روي متغیر وابسته (تورم بذر) تجزیة رگرسیون چند متغیره انجام شد. سپس، تجزیة رگرسیون گام به گام بر روي داده‌ها اعمال گردید و معادلة نهایي حاصله از آن نشان داد که عملکرد بذر از میان دیگر خصوصیات مستقل اثر مثبت معني داري بر روي تورم بذر نشان داد.